an interleaver synchronizer that identifies a beginning of an interleaver block based on a location of a correlated peak associated with said signature sequence.

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REMARKS

This Amendment is submitted in response to the outstanding Office Action, dated August 14, 2002, and is accompanied by a petition and fee for extension of time (one month). Claims 1-30 are pending. Claims 1, 12, 22, 29 and 30 have been amended herein. The specification has been amended to correct a number of typographical errors. No additional fee is due.

In the Office Action, the Examiner rejected claims 1-3 under 35 U.S.C. §103(a) as being unpatentable over Dejonghe (United States Patent Number 6,363,084) and Rakib et al. (United States Patent Number 6,307,868). Claim 4 was rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe and Rakib et al. and further in view of Ohkubo et al. (United States Patent Number 6,151,369). Claims 5-10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe and Rakib et al. and further in view of Klank et al. (United States Patent Number 6,226,337). Claim 11 was rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe and Rakib et al. and further in view of Van Nee. (United States Patent Number 6,404,732). Claims 12-30 were rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe and Rakib et al. and further in view of Ohkubo, Klank and Van Nee.

The present invention is directed to techniques for estimating the frequency offset and interleaver synchronization in an OFDM communication system. Certain locations in an OFDM frame, such as adjacent bins, are allocated to a signature sequence. Data is differentially encoded in frequency, so that said frequency offset and interleaver synchronization can be estimated from a single OFDM frame. The frequency offset is estimated at a receiver by determining whether a correlated peak associated with said signature sequence is in an expected location. A beginning of an interleaver block is identified based on a location of a correlated peak associated with the signature sequence.

In the Office Action, the Examiner rejected claims 1-3 under 35 U.S.C. §103(a) as being unpatentable over Dejonghe and Rakib et al. The Examiner asserts that Dejonghe discloses a method for estimating the frequency offset in an OFDM communication system, comprising the steps of: allocating certain locations to a signature sequence (Citing Figs. 1 and 2); transmitting said signature

sequence with data to a receiver; and estimating the frequency offset at said receiver by determining whether a correlated peak associated with said signature sequence is in an expected location.

As shown in FIGS. 1 and 2, Dejonghe differentially encodes the signal in *time* (vertically in FIG. 1), by comparing corresponding bins (or carriers) of two adjacent frames (or symbols) C_0 and C_1. Thus, a single frame (or symbol) cannot be decoded at the receiver until the second frame arrives. In addition, the frequency offset cannot be determined unless multiple frames are received. See, also, mathematical expression 1, at col. 4, line 34, where it is clear that the differential value is C_1 multiplied by the complex conjugate of C_0.

Each of the independent claims of the present invention, however have been amended to emphasize that differential decoding is performed in frequency. Support for this limitation is found at, e.g., page 4, lines 26-28. Therefore, the present invention allows the frequency offset to be estimated from a single frame. In other words, the present invention encodes data differentially across the bins (or subcarriers) in frequency of a single frame, while Dejonghe encodes data differentially between the bin of one frame and the corresponding bin of another frame.

Thus, Dejonghe does not disclose or suggest "transmitting said signature sequence with data to a receiver wherein said data is encoded using a differential encoding performed in frequency," as required by independent claims 1 and 22, as amended. Similarly, Dejonghe does not disclose or suggest "wherein said received digital signal is encoded using a differential encoding performed in frequency," as required by independent claims 12, 29 and 30, as amended.

Additional Cited References

Rakib has been cited by the Examiner for its disclosure of details on an interleaver. Rakib does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Ohkubo has been cited by the Examiner for its disclosure of frequency offset correction in an OFDM communication system. Ohkubo does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Klank has been cited by the Examiner for its disclosure of transmitting digital frames using multiple modulated carriers having a given reference frequency pattern. Klank does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Van Nee has been cited by the Examiner for its disclosure of a digital modulation system that provides enhanced multipath performance using modified orthogonal codes. Van Nee does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Dependent Claims

Dependent Claims 2-11, 13-21 and 23-28 were rejected under 35 U.S.C. §103 as being unpatentable over various combinations of Dejonghe, Rakib et al., Ohkubo, Klank and Van Nee. Claims 2-11, 13-21 and 23-28 are dependent on Claims 1, 12 or 22, and are therefore patentably distinguished over Dejonghe, Rakib et al., Ohkubo, Klank and Van Nee (or any combination thereof) because of their dependency from amended independent Claims 1, 12 or 22 for the reasons set forth above, as well as other elements these claims adds in combination to their base claim.

In view of the foregoing, the invention, as claimed in Claims 1-30, cannot be said to be either taught or suggested by Dejonghe, Rakib et al., Ohkubo, Klank and Van Nee (or any combination thereof). Accordingly, applicants respectfully request that the rejection of the claims under 35 U.S.C. §103 be withdrawn.

All of the pending claims, i.e., claims 1-30, are in condition for allowance and such favorable action is earnestly solicited.

If any outstanding issues remain, or if the Examiner has any further suggestions for expediting allowance of this application, the Examiner is invited to contact the undersigned at the telephone number indicated below.

The Examiner's attention to this matter is appreciated.

Respectfully submitted,

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VERSION MARKED TO SHOW CHANGES

IN THE SPECIFICATION:

Please amend the paragraph beginning at page 1, line 5, as follows:

The present invention is related to United States Patent Application Serial Number 09/396,058, entitled "Method And Apparatus For Partial And Course Frequency Offset Estimation In A Digital Audio Broadcasting (DAB) System," [(Attorney Docket Number Milbar 1-9),] filed contemporaneously herewith, assigned to the assignee of the present invention and incorporated by reference herein.

Please amend the paragraph beginning at page 1, line 12, as follows:

The present invention relates generally to digital audio broadcasting [(DAB)] and other types of digital communication systems, and more particularly, to frequency offset estimation techniques for such digital audio broadcasting [(DAB)] and other types of digital communication systems.

Please amend the paragraph beginning at page 1, line 18, as follows:

Proposed systems for providing digital audio broadcasting [(DAB)] in the FM radio band are expected to provide near CD-quality audio, data services and more robust coverage than existing analog FM transmissions. However, until such time as a transition to all-digital DAB can be achieved, many broadcasters require an intermediate solution in which the analog and digital signals can be transmitted simultaneously within the same licensed band. Such systems are typically referred to as hybrid in-band on-channel (HIBOC) DAB systems, and are being developed for both the FM and AM radio bands.

Please amend the paragraph beginning at page 4, line 6, as follows:

FIG. 1 shows a portion of a frequency spectrum in an exemplary hybrid in-band on-channel [(HIBOC)] digital audio broadcasting [(DAB)] system in accordance with the present invention;

FIG. 2 is a schematic block diagram of a transmitter in an exemplary hybrid in-band on-channel [(HIBOC)] digital audio broadcasting [(DAB)] system in which the present invention may be implemented;

FIG. 3 illustrates the format of a signature OFDM frame in accordance with the present invention; and

FIG. 4 is a schematic block diagram of an exemplary receiver in a hybrid in-band on-channel [(HIBOC)] digital audio broadcasting [(DAB)] system in which the present invention may be implemented.

IN THE CLAIMS:

Please amend the claims as follows:

1. (Amended) A method for estimating the frequency offset in an OFDM communication system, comprising the steps of:

allocating certain locations in an [interleaver] OFDM frame to a signature sequence;

transmitting said signature sequence with data to a receiver, wherein said data is encoded using a differential encoding performed in frequency; and

estimating the frequency offset at said receiver by determining whether a correlated peak associated with said signature sequence is in an expected location.

12. (Amended) A method for estimating the frequency offset in an OFDM communication system, comprising the steps of:

receiving a digital signal, wherein said received contains a signature sequence in an expected location, wherein said received digital signal is encoded using a differential encoding performed in frequency;

correlating said received digital signal using a filter matched to said signature sequence; and

identifying whether a correlated peak associated with said received digital signal is an expected location.

22 (Amended) A method for synchronizing interleavers in an OFDM communication system, comprising the steps of:

allocating certain locations in an [interleaver] OFDM frame to a signature sequence;

transmitting said signature sequence with data to a receiver, wherein said data is encoded using a differential encoding performed in frequency; and

identifying a beginning of an interleaver block based on a location of a correlated peak associated with said signature sequence.

29 (Amended) A receiver in an OFDM communication system for receiving a digital signal containing a signature sequence in an expected location, comprising:

a filter matched to said signature sequence for correlating said received digital signal, wherein said received digital signal is encoded using a differential encoding performed in frequency; and

a frequency offset estimator that identifies whether a correlated peak associated with said received digital signal is an expected location.

30 (Amended) A receiver in an OFDM communication system, comprising:

means for receiving a digital signal having a signature sequence in certain locations, wherein said received digital signal is encoded using a differential encoding performed in frequency;

a filter matched to said signature sequence for correlating said received digital signal; and

an interleaver synchronizer that identifies a beginning of an interleaver block based on a location of a correlated peak associated with said signature sequence.